CMPS 312

Read Chapter 1

Android Fundamentals

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Outline

1. Introduction to Android
2. Android Programming Model

Introduction to Android

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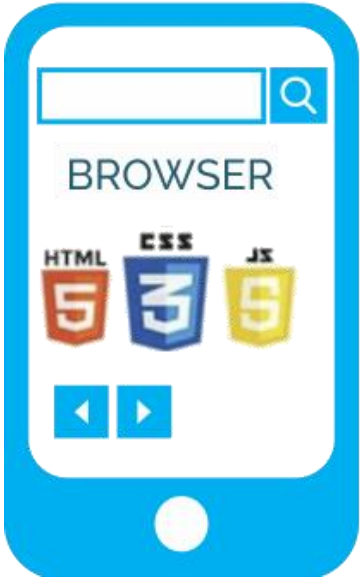
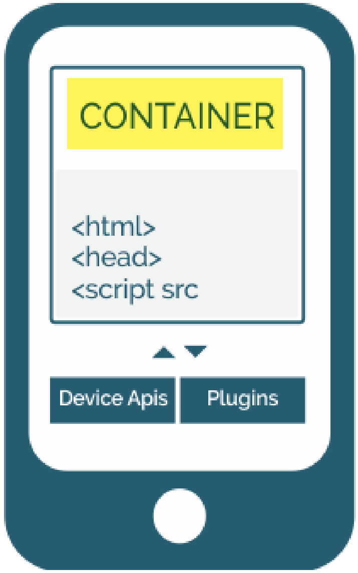
Why learn app development?

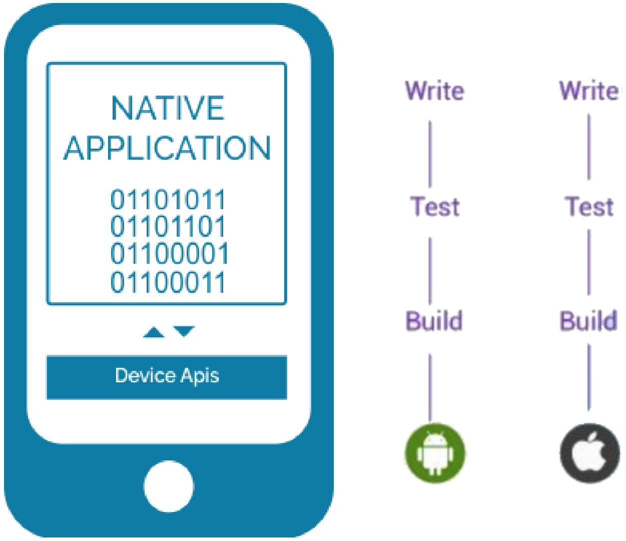
- Smart devices are ubiquitous
  - Estimated 3.5 billion smartphones + tablets, smart watches, IoT devices...
  - Apps interwoven into daily life – work, play, study
  - Mobile = **dominant** end-user device. It represents and intimately “knows” the user: much more than just a small computer, it represents the user
  - Brings in outside world: **sensing**, **location**, **communication**
- Apps less expensive and more portable
- Large market opportunity for businesses and developers

Types of mobile development: Web vs Hybrid vs Native

IMPORTANT



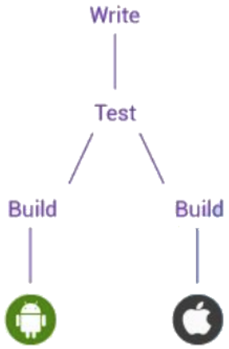




Web Apps

- Multi-platform
- Leverage existing web dev skillset and code
- Web UI: Run in browser or WebView (can be offline)
- Least access to hardware, sensors, OS
- Slower performance

Hybrid Apps

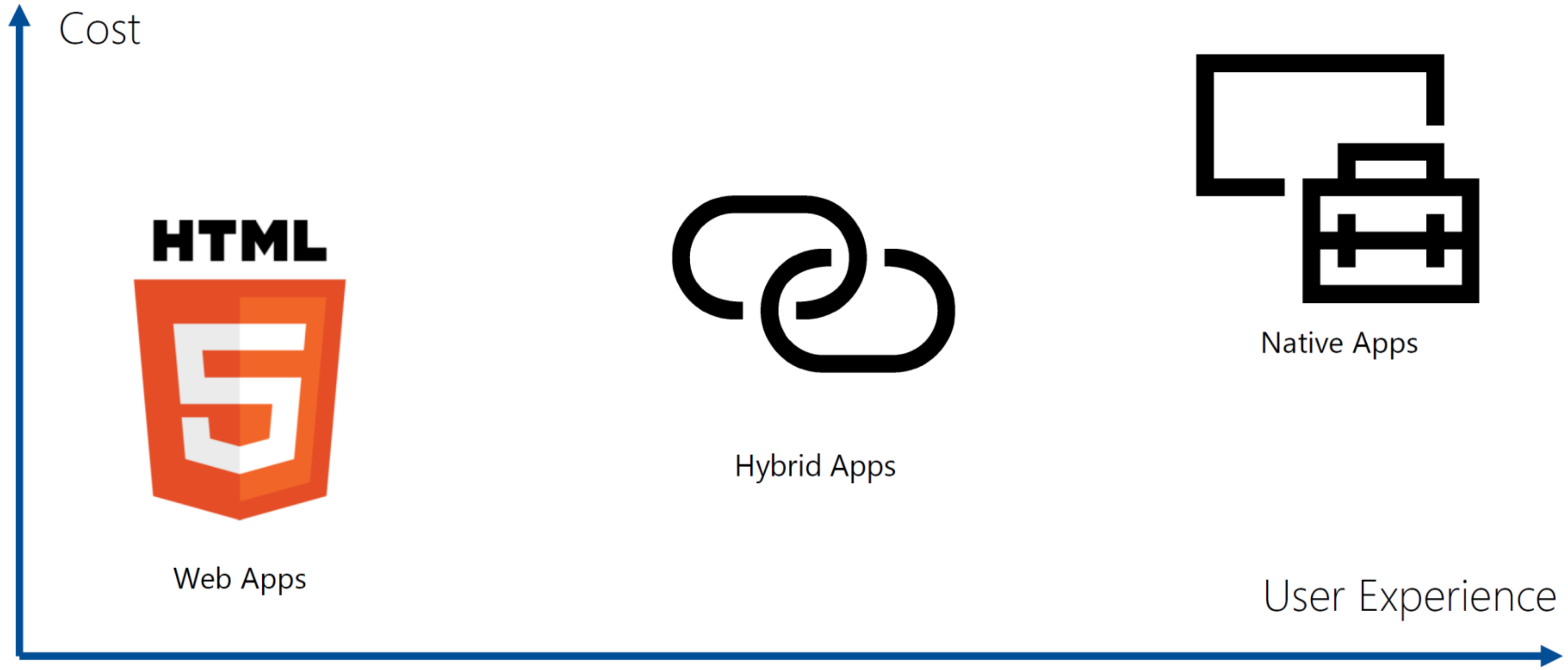


- Shared codebase for iOS & Android
- Leverage web dev skillset and code
- Web app hosted in a **native app shell** to mediate access to hardware, sensors, OS

Native Apps

- Single platform iOS or
- Native UI and best user experience
- Run directly on OS: Fast performance
- Best system Integration: Full access to hardware, sensors, OS
- More expensive: requires **multiple code bases** and teams

Web vs Hybrid vs Native



Cost

Native Apps

Hybrid Apps

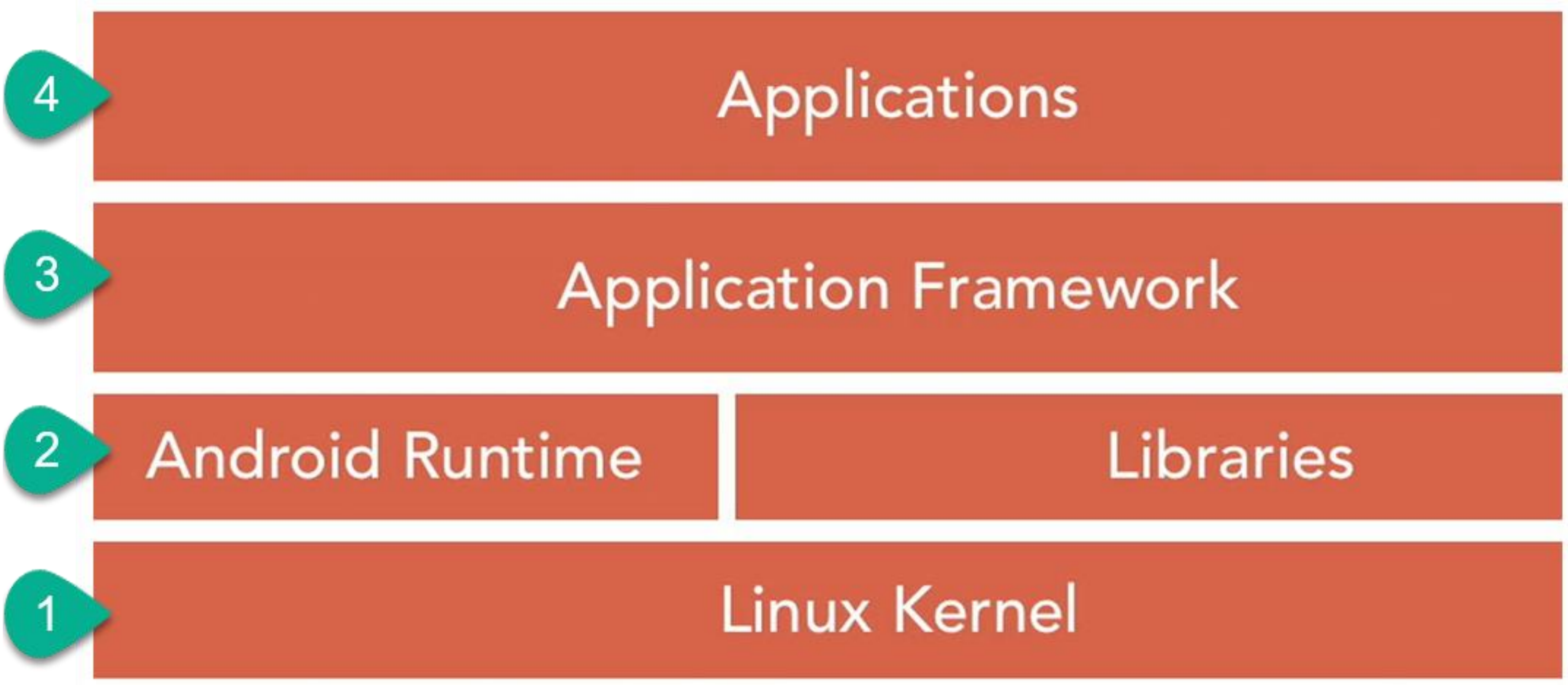
Web Apps

User Experience

What is Android?

- Open source mobile operating system (OS) based on Linux kernel for phones, tablets, wearable
  - originally purchased by Google from Android, Inc. in 2005
- The #1 OS worldwide
  - Used on over 80% of smartphones
  - As of 2019, over 2.5 billion Android devices worldwide
  - Over 2 Million Android apps in Google Play store
- Highly customizable for devices by vendors

Android Software Stack



1. Interacts and manages hardware
2. Expose native APIs & run apps
3. Java API exposing Android OS features
4. System and user apps (e.g., contacts, camera)

Android Software Stack

1. Optimized **Linux Kernel** for interacting with the device's processor, memory and hardware drivers (e.g., WiFi Driver)
   - Acts as an abstraction layer between the hardware and the rest of the software stack
2. **Android runtime (ART)** = Virtual Machine to run Apps
   - Each app runs in its own process and with its own instance of the Android Runtime that controls the app execution (e.g., permission checks) in isolation from other apps
   - Expose native APIs and OS Core Libraries including 2D/3D graphics, Audio Manager, SQLite database, encryption …
3. **Application Framework**: Java APIs (Application Programming Interfaces) make Android OS features available to Apps (e.g., Activity Manager that manages the lifecycle of apps)

https://developer.android.com/guide/platform

Android Programming Model

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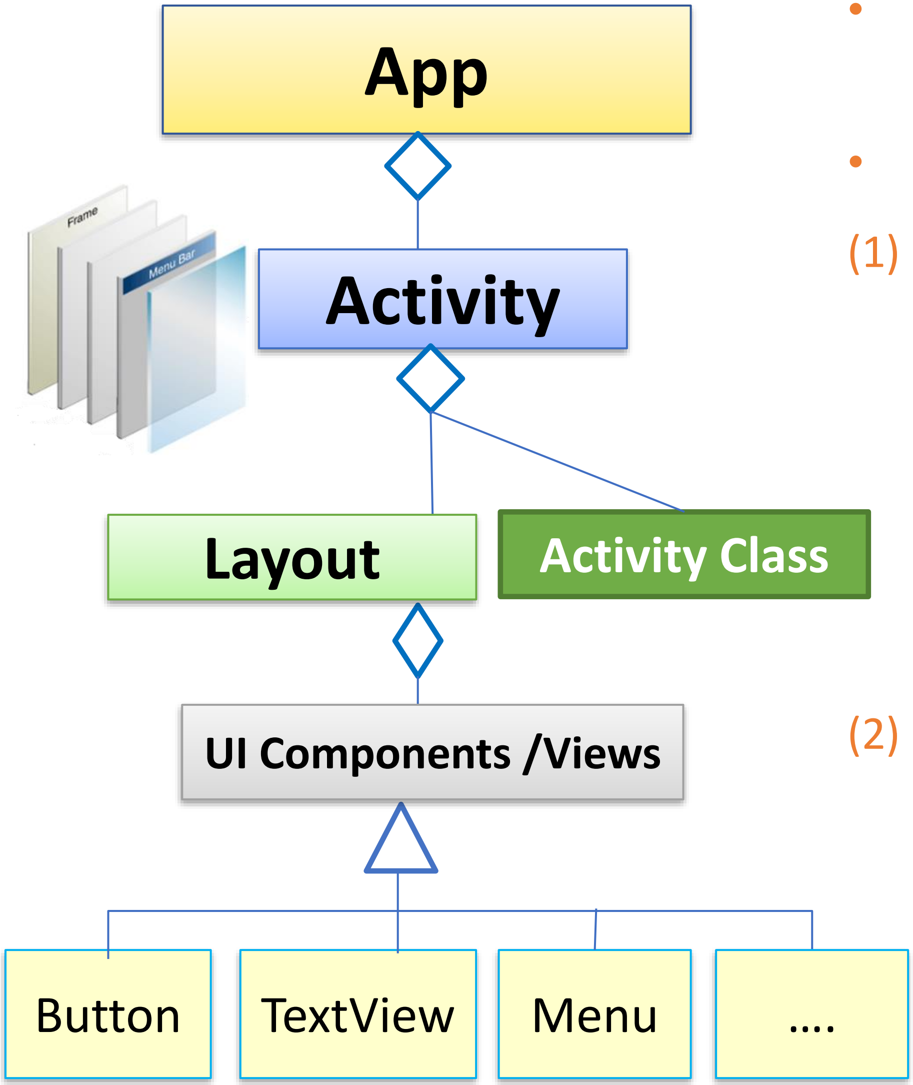
Imperative UI - old
Android Programming Model



- App is composed of one or more **screens** (called **Activity**)
- An **activity** has:

(1) a **Layout** that define its appearance (how it **looks like**)

- ○ Layout acts as a **container** for UI Components (called **View**)
- ○ It decides the size and position of views placed in it

(2) Activity Kotlin class that provides the data to the UI and handles events

- ○ UI Components **raise** **Events** when the user interacts with them (such as a Clicked event is raised when a button is pressed).
- ○ In the activity class we define **Event Handlers** to respond to the UI events

Activity

- **Activity** provides the UI that the user interacts with
  - Allow the user to do something such as order groceries, send email
  - Has **layout** (.xml) file & **Activity class**
  - This allows a **goode separation** between the UI and the app logic
- Connecting activity with the layout is done in the **onCreate** method

```
setContentView(R.layout.activity_main)
```

- Activity class defines listeners to handle events:
  - User interaction events such press a button or enters text in a text view
  - External events such as receiving a notification or screen rotation

Example

```
class MainActivity : AppCompatActivity() {
    override fun onCreate(savedInstanceState: Bundle?) {
          super.onCreate(savedInstanceState)
          setContentView(R.layout.activity_main)

          changeColorBtn.setOnClickListener {
              greetingTv.setTextColor(getRandomColor())
          }
    }
```

Connects activity with layout

Event Driven Programming

- GUI programming model is based on **event driven programming**
  - Code is executed upon activation of events
- An **event** is a signal from Android system that some something of interest to the app has occurred
  - UI Events (click, tap, swipe, drag)
  - Input focus (gained, lost)
  - Keyboard (key press, key release)
  - Activity events (e.g., onCreate, onRestart)
  - Device: DetectedActivity such as walking, driving, tilting
- When an event is triggered, an event handler can run to respond to the event. e.g.,
  - When the button is clicked -> load the data from a file into a list

Imperative UI vs. Declarative UI

👑 In **Imperative UI**, a UI entity is fully defined and then it is updated using public methods and/or properties (e.g., Android View class)

📢 In **Declarative UI**, the UI and its state are defined together, and a framework has the responsibility to update UI automatically to reflect state changes

Imperative vs. Declarative UI

Imperative:

“ a programming paradigm that uses statements that change a program's state” - Wikipedia

- Lots of boilerplate and boring code
- Errors and bugs prone
- Hard to maintain

Declarative: Describe WHAT to see NOT HOW

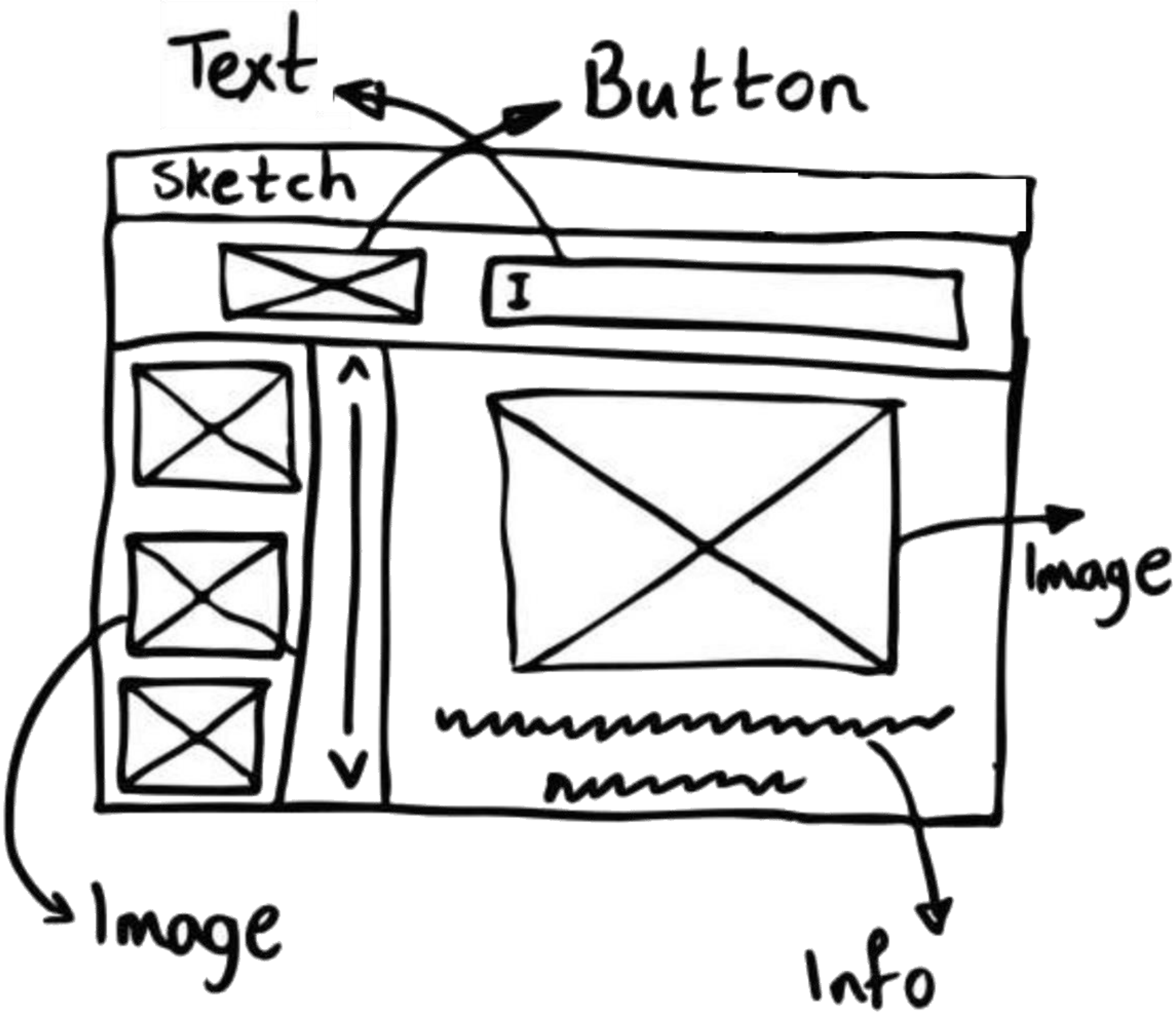
“ **what** the program should accomplish without specifying how the program should achieve the result” - Wikipedia

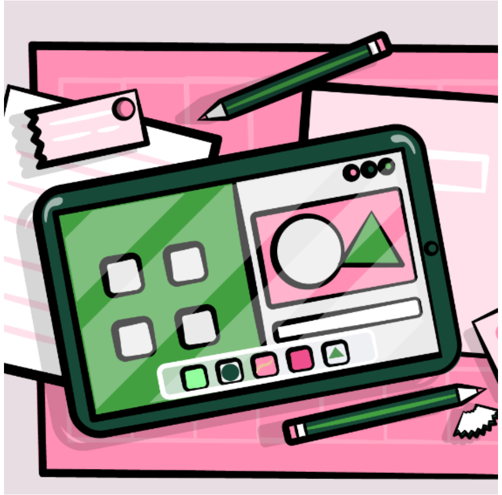
✓ Less code to write → Fewer bugs and more flexible

Steps to creating a GUI Interface

1. Design it on paper (sketch)
   - Decide what information to present to the user and what input they should supply
   - Decide the UI components and the layout on paper
2. Create a layout and add UI components to it
3. Add event handlers to respond to the user actions
   - Do something when the user presses a button, selects an item from list, change text of input field, etc.

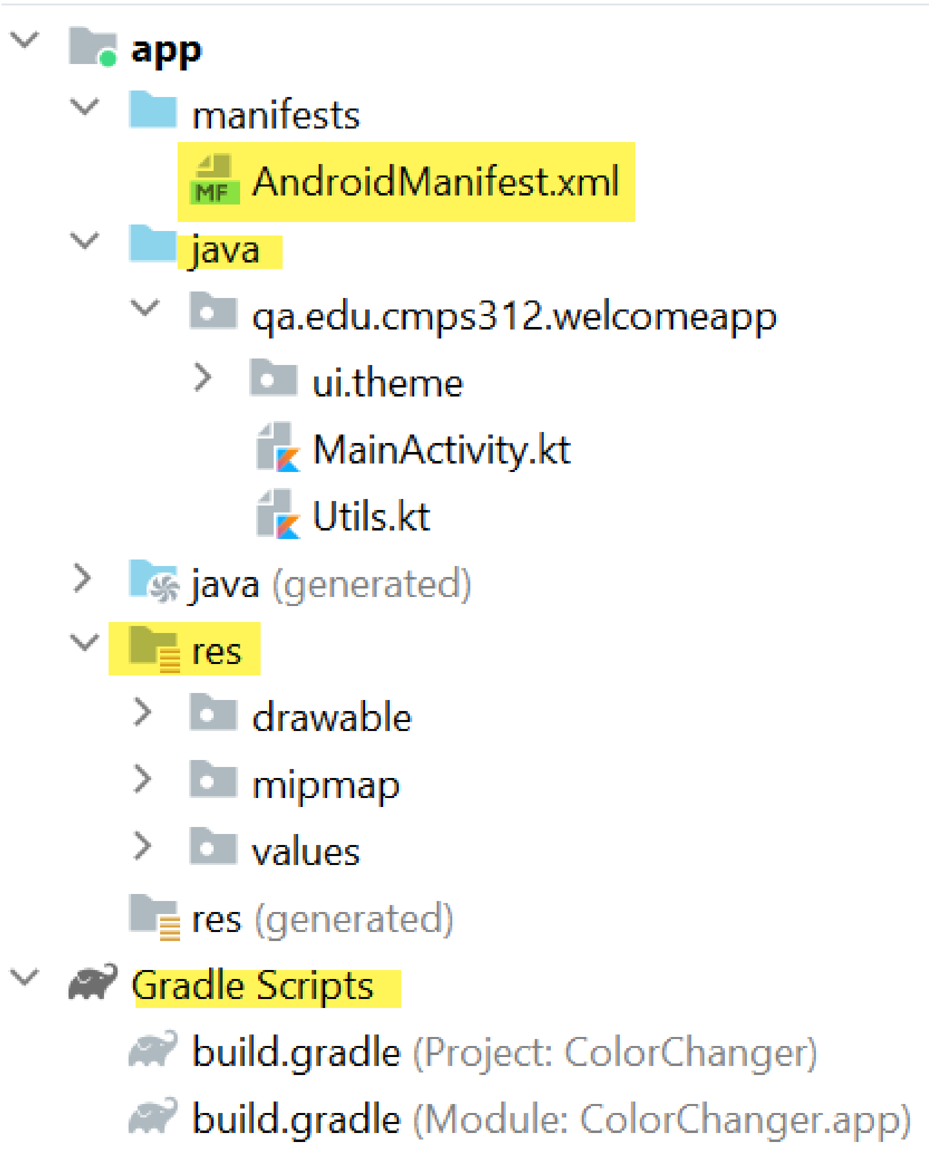
UI Sketch - Example





You may design different layouts per screen size

Project structure



```
app
  manifests
    AndroidManifest.xml
  java
    qa.edu.cmps312.welcomeapp
      ui.theme
      MainActivity.kt
      Utils.kt
  java (generated)
  res
    drawable
    mipmap
    values
  res (generated)
Gradle Scripts
  build.gradle (Project: ColorChanger)
  build.gradle (Module: ColorChanger.app)
```

- **AndroidManifest.xml**
  - app config and settings (e.g., list app activities and required permissions)
- **java/...**
  - Kotlin source code
- **res/...** = resource files *(many are **XML**)*
  - drawable/ = images
  - Mipmap = app/launcher icons
  - values/ = Externalize constant values
- **Gradle**
  - a build/compile management system
  - **build.gradle** = define config and dependencies (one for entire project & other for app module)

Resources

- Android Kotlin Fundamentals Course
  - https://codelabs.developers.google.com/android-kotlin-fundamentals/
  - https://developer.android.com/courses/android-basics-kotlin/course
- Android Dev Guide
  - https://developer.android.com/guide/